Natural History & Biodiversity

HIGH ABUNDANCE AND LOW DIVERSITY OF FOSSIL TETRAPOD VERTEBRATES IN THE SOLITE QUARRY (VIRGINIA-NORTH CAROLINA, UPPER TRIASSIC, 225 MILLION YEARS AGO). Alexander K. Hastings & Christina J. Byrd, Virginia Museum of Natural History, 21 Starling Avenue, Martinsville, VA 24112. The Solite Quarry, which spans the Virginia-North Carolina border, contains a Late Triassic (ca. 225 million-year-old) shale deposit with thousands of fossil plants, insects, and vertebrates. Among the plant fossils preserved, cycad fronds and stems of conifers are common. Numerous fossil insects and other arthropods have been collected from a three cm thick unit, including over 2,400 individual specimens, with many more to be catalogued. The dominance of aquatic insects suggests a shallow lake basin, but the phenomenal preservation and black sediments suggest a deeper, anaerobic setting. In either case, the site represents a relatively low-energy freshwater lake environment. 484 vertebrate fossils have been collected thus far. The rarest vertebrate species is the gliding reptile *Mecistotrachelos apeoros*, which was likely non-aquatic. Fish account for at least 140 of the vertebrates, including coelacanths, semionotiforms, and palaeonisciforms. The remaining 340 vertebrate specimens belong to the aquatic reptile *Tanytrachelos ahynis*. Based on this sample, over 70% of the vertebrates and over 98% of the tetrapods belonged to a single species. The high abundance of insects and low abundance of predatory competition may explain why the *Tanytrachelos* are so common at Solite. Despite a high level of sampling, there appears to be very low levels of tetrapod alpha diversity during the Triassic of this region.

TESTING THE CEPHALIC ADHESIVE ORGAN HYPOTHESIS IN CYPRINID PROTOLARVAE. George E. Maurakis, College of Science, Virginia Tech, Blacksburg VA 24061. The objective of this research is to test the hypothesis that protolarvae of the phytophilous species, *Hybognathus hankinsoni*, *Notemigonus crysoleucas*, *Carassius auratus*, and *Cyprinus carpio* (Cyprinidae), contain cephalic adhesive glands. The hypothesis is if newly hatched larvae of phytophilous species attach to aquatic vegetation, then they have adhesive glands. SEM examination of 11 areas around the head (including dorsal, lateral, and ventral) of each specimen indicated there were no adhesive organs on the control species (*S. corporalis)*, or test species (*H. hankinsoni, N. crysoleucas, C. auratus*, and *C. carpio*). The hypothesis that if newly hatched protolarvae of the phytophilous species attach to aquatic vegetation, then they have adhesive organs, is rejected. Both SEM and light microscopy indicated the absence of adhesive organs on all areas of heads of all control and test protolarvae. The control species (*S.*

corporalis) only had epithelial pores with no epidermal mucus. Although test species did not have adhesive organs, all of them had both epithelial pores and epidermal mucus. This mucus is probably responsible for the adhesion of protolarvae to aquatic vegetation, a hypothesis that could be tested in the future. Light microscopy indicated that the control species (*S. thoreauianus*) had a two cell-thick epidermis, whereas the epidermis of *N. crysoleucas* was about three to four cell layers thick. The three to four cell layer thick epidermis of *N. crysoleucas* is significant as some cells were goblet cells opening outside of the epidermis. Goblet cells have been reported to contain mucus (mucopolysaccharides), which can serve as an adhesive substance.

EVOLVING ISOLATION MECHANISMS AMONG HOST-FOODPLANT SOURCES OF A PARASITIC WASP SPECIES. Justin P. Bredlau & Karen M. Kester, Integrative Life Sciences & Department of Biology, Virginia Commonwealth University, Richmond VA 23284. Parasitic wasps are highly diverse and play a major role in suppression of herbivorous pest populations. Recent research has demonstrated that previously identified species of some parasitic wasps are actually complexes of cryptic species resulting from adaptations to specific hosts or host foodplants. *Cotesia congregata* (Braconidae) is reported to attack at least 15 species of sphingid caterpillars, most of which are plant family specialists. We expanded on our earlier finding that wasps from *Manduca sexta* on tobacco ("MsT") and *Ceratomia catalpae* ("CcC") represent distinct genetic lineages with both pre- and post-zygotic barriers to reproduction by testing for post-zygotic barriers to reproduction among wasps from additional host-foodplant complexes. Wasps were collected from five host sources in two subfamilies of Sphingidae: MsT, CcC, and *Sphinx kalmiae* on privet ("SkP") (Sphinginae), and *Darapsa myron* and *Eumorpha pandorus* from wild grape and Virginia creeper ("DmV" and "EpV") (Macroglossinae). Reciprocal hybrid crosses were established between MsT and CcC wasps with each of these additional sources to test for the production of viable fertile hybrids. All reciprocal crosses produced hybrid females. Most hybrid females from CcC♂xMsT♀, CcC♂xEpV♀, SkP♂xMsT♀, and DmV♂xMsT♀ failed to produce F_2 offspring, whereas the reciprocal crosses produced viable offspring. Dissections of hybrid females revealed that sterile wasps lacked mature ovaries. The pattern of asymmetric hybrid dysgenesis indicates that *C. congregata* is diverged into at least two reproductively isolated groups.

COMPARATIVE THERMAL PERFORMANCE IN A CATERPILLAR-PARASITOID-HYPERPARASITOID TRI-TROPHIC SYSTEM. Kanchan Anand Joshi[1], Salvatore J. Agosta[2] & Karen M. Kester[1], [1]Department of Biology and [2]Center for Environmental

Studies, Virginia Commonwealth University, Richmond VA, 23284. Among the predicted impacts associated with global climate change, the effects of warming on organismal performance are of special interest because the rates of all physiological processes are temperature-dependent. Ectotherms such as insects, which are the most abundant and speciose animal taxon, are likely to be most affected due to their limited ability to control body temperature. Further, responses are likely to vary among species, which may have significant consequences for the dynamics of species interactions, such as those between hosts and parasites. In this study, we measured tolerance to extreme high temperatures, i.e., critical thermal maximum (CT_{max}) to test differences among component species in a tri-trophic system including a caterpillar, *Manduca sexta*, a parasitoid wasp, *Cotesia congregata*, and a hyperparasitoid in the genus *Spilochalcis*. Critical thermal tolerance (CT_{max}) varied significantly among the component species. The parasitoid wasp had the lowest CT_{max} and the hyperparasitoid had the highest CT_{max}. Both unparasitized and parasitized caterpillars had CT_{max} values that were intermediate between the parasitoid and hyperparasitoid. Our results demonstrate that species involved in multi-trophic interactions can vary in their tolerances to high temperatures and suggest that climate change may result in disruption of these interactions.

THE CENTER FOR BIODIVERSITY AT JOSEPH PINES PRESERVE. Philip M. Sheridan, Meadowview Biological Research Station, 8390 Fredericksburg Tnpk., Woodford, VA 22580. The Center for Biodiversity is a 1.5 acre parcel with a 3000 s.f. building adjacent to Meadowview's 232 acre Joseph Pines Preserve. The Center supports the conservation, protection, and restoration of the endangered longleaf pine/pitcher plant ecosystem in Virginia. The Center allows Meadowview staff to train students and the general public about the need and value of rare plant and animal conservation, support ongoing scientific research and restoration efforts at the Joseph Pines Preserve, and demonstrate how a sustainable lifestyle can support habitat restoration. The Center property is part of a conservation plan to acquire over 2000 contiguous acres and provide one of the largest and best managed examples of a longleaf pine ecosystem in a multi-state area. This property represents the northern limit of the known range of the longleaf pine ecosystem. Habitat restoration has included mechanical clearing, chemical site treatments, prescribed fire, and controlled reintroductions of 18 indigenous rare plant taxa (including one federally endangered species). Habitat is also provided for one federally endangered bird species (red-cockaded woodpecker), one state threatened bird species (Bachman's sparrow), and one endangered fish species (black-banded sunfish).

PRESCRIBED FIRE INCREASES PLANT SPECIES RICHNESS IN RESTORED VIRGINIA LONGLEAF PINE HABITATS. Philip M. Sheridan[1] & Alex Petzke[2]. [1]Meadowview Biological Research Station, 8390 Fredericksburg Tnpk., Woodford, VA 22580. [2]Department of Environmental and Forest Biology, State University of New York College of Environmental Science and Forestry, Syracuse, NY. Longleaf pine forests are known for high plant species diversity. A number of research studies in the southeastern U.S. support the hypothesis that high plant species diversity in longleaf pine forests is enhanced by disturbance provided by frequent fire. We were interested in determining whether this hypothesis was supported in longleaf pine restoration sites in Virginia, when Virginia longleaf pine habitats might rival plant diversity found in southeastern U.S. longleaf pine habitats, and if herbicide had a negative effect on plant diversity. We collected data on two longleaf pine nature preserves in Sussex and Prince George County, VA (Cherry Orchard Bog Preseve and Joseph Pines Preserve) and found that plant diversity increased over time with prescribed fire. We predict that Virginia longleaf pine forests, managed with regular prescribed fire, could achieve 50 species/m^2 within 48 years and rival diversity found in their southeastern counterparts. We also found that herbicide did NOT have a negative effect on plant diversity.

RESTORING GROUNDWATER HYDROLOGY IN A VIRGINIA PITCHER PLANT SEEPAGE WETLAND. Marissa Merhout & Philip M. Sheridan. Meadowview Biological Research Station, 8390 Fredericksburg Tnpk., Woodford, VA 22580. Pitcher plant habitats in southeastern Virginia are typically located on 0 order headwater seepage wetlands with marine deposits of sandy to sandy loam soils. Frequent fire is important in keeping pitcher plant habitats open and preventing the encroachment of competing vegetation. We initiated a longleaf pine/pitcher plant ecosystem habitat restoration program at our Joseph Pines Preserve in Sussex County, VA that included an aggressive assault on competing woody plant species. We observed an increase in groundwater in our seepage bogs after treatment of woody plant competitors and conducted graduate and intern research to measure the effects of woody plant control on groundwater hydrology at our preserve. We found that conversion of a dense mixed oak/pine forest to longleaf pine savanna resulted in a 25% reduction in evapotranspiration, or a retention of almost 4 million gallons of water/ year on a 24 acre watershed. We also found that seepage bog pore water was potable and met state certified lab criteria as drinking water with a t.d.s of 9. We found that rainfall enters the ground water column within two days of a rain event. These results indicate that Virginia pitcher plant wetland hydrology is very sensitive to woody plant invasion, that pitcher plant seepage water is very clean, and that surface activities could quickly contaminate the aquifer.

GENETIC CONNECTIVITY OF RACOONS (*PROCYON LOTOR*) IN A NATURALLY FRAGMENTED COASTAL LANDSCAPE: EVIDENCE FROM MITOCHONDRIAL AND MICROSATELLITE MARKERS. N. D. Moncrief[1], J. H. Roberts[2], E. M. Hallerman[3], R. A. Van Den Bussche[4] & R. D. Dueser[5], [1]VA Museum of Natural History, Martinsville, VA 24112, [2]Dept. of Biol., Georgia Southern Univ., Statesboro, GA 30458; [3]Dept. of Fish and Wildlife Conservation, Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061; [4]Dept. of Integrative Biol., Oklahoma State Univ., Stillwater, OK 74078 and [5]Dept. of Wildland Resources, Utah State Univ., Logan, UT 84322. We used mitochondrial (mtDNA) and nuclear DNA markers to identify past and present dispersal corridors of raccoons (*Procyon lotor*) on the Virginia barrier islands and adjacent Delmarva Peninsula mainland. We found complex patterns of spatial population structure and migration rates in this system. Results of this study suggest that the metapopulation structure of raccoons on the Virginia barrier islands is highly dynamic, with most movement of raccoons occurring among groups of islands that are inter-connected by marsh and relatively shallow, narrow, open-water channels. These results are consistent with our direct observations of overwater movement by raccoons within this system. These genetic data also support predictions from our models based on cost-distance analysis of landscape resistance to movement by raccoons among islands and the mainland.

MORPHOMETRIC DIVERGENCE AND FUNCTIONAL SIMILARITY IN *SCIURUS VULGARIS* (EURASIAN RED SQUIRREL) AND *SCIURUS CAROLINENSIS* (EASTERN GRAY SQUIRREL). J. S. Scheibe, Dept. of Biology, Southeast Missouri State Univ., Cape Girardeau, MO 63701 & N. D. Moncrief, Va. Museum of Natural History, Martinsville, VA 24112. We used geometric morphometric techniques to explore and compare the shapes of dentaries and skulls in 4 species of tree squirrels: Eurasian red squirrel (*Sciurus vulgaris*), eastern gray squirrel (*S. carolinensis*), eastern fox squirrel (*S. niger*), and western gray squirrel (*S. griseus*). These species were chosen because of current competitive interactions amongst the species, and because of their phylogenetic affinities. A canonical variates analysis of Procrustes shape coordinates revealed significant shape differences between the skulls and dentaries of *S. carolinensis* and *S. vulgaris*. We compared biomechanical properties of the dentaries for the 4 species, and used discriminant functions analysis to discriminate between the species in a jaw-function space. Here, there was extensive functional overlap between *S. carolinensis* and *S. vulgaris*, but not between *S. carolinensis* and *S. niger*. Although the skulls and dentaries of *S. carolinensis* and *S. vulgaris* differ morphologically, they are functionally similar.

AN EVALUATION OF THE EXTINCTION RISK OF THE FISH ORDER SCORPAENIFORMES IN THE OCEANIA REGION. J. Deal[1], H. Motomura[2], G. Ralph[3,4], K. Carpenter[3,4], and H. Harwell[1], [1]Dept. of Organismal and Environmental Biology, Christopher Newport University, [2]Kagoshima University Museum, [3]Old Dominion University, [4]Marine Biodiversity Unit, Global Species Programme, International Union for Conservation of Nature. The remote region of Oceania is home to high species diversity and endemism, yet the conservation status of many of these species remains unknown. This project is part of a large, collaborative effort to complete the first comprehensive assessment of the relative extinction risk of all marine bony fishes of the Oceania region. Here, we present results for three families of the fish order *Scorpaeniformes*. Species-specific information regarding taxonomy, distribution, population status, habitat, ecology, potential threats, and current conservation measures was compiled from available literature for each member of the families Dactylopteridae, Platycephalidae, and Scorpaenidae occurring within the region. These data were verified and supplemented by leading scientific experts at a Red List Assessment Workshop held in Suva, Fiji, in March 2015. Applying Red List Criteria, each species was assigned a Red List Category of relative extinction risk. Species-specific digital distribution maps were compiled to identify geographic areas of high species richness and potential areas of concern. Eighty-six per cent of the species included were listed as Least Concern and 12% were listed as Data Deficient; however, two species endemic to the Hawaiian Islands (*Caracanthus typicus* and *Sebastapistes coniorta*) were listed as Near Threatened. This information will help guide future marine conservation and fisheries management efforts within the region.

SPATIAL AND TEMPORAL PATTERNS OF VEHICLE COLLISION-INDUCED WILDLIFE MORTALITY IN CENTRAL VIRGINIA. J. Gibson, G. Cole, E. Robertson & S. Henkanaththegedara, Department of Biological & Environmental Sciences, Longwood University, Farmville, VA 23909. Roads could pose significant ecological impacts on environment and wildlife communities. Wildlife mortality due to vehicle collisions is one of the leading causes for population declines, population fragmentation and potentially, local extirpations. The impact of vehicle collisions on wildlife mortality in Virginia is poorly documented. We assessed the influence of road type (2-lane and 1-lane), seasons (spring and fall) and adjacent habitats (forest, agriculture and developed) on average animal mortality rate. Highest mortality rates were reported for gray squirrel (30%) followed by Virginia opossum (16%) and white-tailed deer (12%). A significantly higher rate of average mortality was recorded for 1-lane highway (40 total) compared to 2-lane highway (22 total). Although we observed more mortalities in spring 2016 (36) compared

to fall 2015 (26), we failed to detect any seasonal effects. There was more wildlife mortality reported in road segments adjacent to forests (37) followed by agriculture (16) and developed (4). However, we failed to detect any significant habitat effects on average mortality rate. Understanding ecological implications of collision-induced wildlife mortality is important in implementing conservation measures.

POTENTIAL IMPACTS OF A CHANGING CLIMATE ON WINTERING BIRD POPULATIONS OF CENTRAL PIEDMONT VIRGINIA. E. Salamon, C. Labosier & S. Henkanaththegedara, Department of Biological & Environmental Sciences, Longwood University, Farmville, VA 23909. Global climate change is significantly altering the structure and functioning of many ecosystems, and temporal and spatial patterns of wildlife populations. Previous studies have shown a decline in common wintering bird populations in the Eastern United States. We assessed long-term trends of local climate and wintering bird species together with any correlations between them. Bird population sizes for 76 wintering bird species were collected from Christmas Bird Count (CBC) database and 53 species with significant trends were included in this analysis. Bird data were collected from Darlington Heights, Lynchburg, Warren, Lake Anna and Gordonsville CBC count circles. Climate data (18 variables) were collected from National Oceanic and Atmospheric Administration's (NOAA) Climatic Data Center (NCDC). Long-term climate trends, bird population trends and correlations between climate variation and bird population sizes were analyzed using linear regression models. Significant trends for number of extreme minimum temperature days for November ($P < 0.01$) and number of days in month with maximum temperature less than or equal to 0 C^0 for December ($P < 0.01$) suggest a warming winter. We observed significant population declines for several bird species (field sparrow, song sparrow, fox sparrow, wood duck, winter wren and downy woodpecker) correlated with above weather changes.

ECTOSYMBIOTIC RELATIONSHIPS BETWEEN THE APPALACHIAN BROOK CRAYFISH (*CAMBARUS BARTONII*) AND THE BRANCHIOBDELLIDAN, *CAMBARINCOLA INGENS* INVOLVING DISSOLVED OXYGEN UPTAKE AND GILL BACTERIA. Thomas P. Holman, Joseph E. Davis & Kyle J. Harris, Department of Biology and Chemistry, Liberty University, Lynchburg VA 24515. Ectosymbiotic relationships between crayfish (*Cambarus bartonii*) and the segmented worms, branchiobdellidans (*Cambarincola ingens*), have shown a cleaning symbiosis that includes the removal of bacteria from the crayfish gill filaments. Eleven *C. bartonii* were randomly divided into two groups. The control group (N=5) had no worms and the experimental group (N=6) had four worms each. The

crayfish were monitored in individual 10 gallon aquaria over twenty weeks. It was expected that the presence of worms would decrease the amount of bacteria in the gill chamber, thus allowing an increase in both growth rates and dissolved oxygen (DO) uptake. A gill chamber bacterial analysis and characterization showed that the logged mean number of colony forming units/gram crayfish ($\log_{10}$ CFUs/g) was greater for the experimental group (3.80 $\log_{10}$ CFUs/g) than the control group (2.84 $\log_{10}$ CFUs/g). The observed percent change in blotted wet mass (BWM) over eight weeks showed that the control group grew 26.2% more than the experimental group. However, this difference in BWM percent change could be due to the variation of initial BWM between control and experimental groups. No significant difference was found in the mean DO consumption between control (0.094 mg/l/g*2hr) and experimental (0.090 mg/l/g*2hr) groups.

MESOCOSM EXPERIMENTS REVEAL NEGATIVE IMPACTS OF INVASIVE RED-SWAMP CRAYFISH ON NATIVE PIEDMONT CRAYFISH. D. Conner, C. Perry, P. Hale, J. Wilson & S. Henkanaththegedara, Department of Biological & Environmental Sciences, Longwood University, Farmville, VA 23909. Previous laboratory experiments showed that invasive red-swamp crayfish (*Procambarus clarkii*) have mixed effects on native Piedmont crayfish (*Cambarus* sp. C). Invasive crayfish had higher levels of aggression towards natives and they outcompeted native crayfish for food. However, there were no significant differences of survival between native and invasive crayfish under sympatry for 120 hours. Although laboratory experiments are informative, the results may be limited by the simplicity of the experimental setup. Therefore it is critical to generate more realistic data to better inform conservation practitioners. We conducted preliminary mesocosm experiments under semi-natural conditions using 360 gallon tanks. We stocked invasive and native crayfish in allopatry and sympatry, and ran the experiments for 21 days. Native crayfish survival was 58% under sympatry, when allopatric survival rate was 94%. Invasive crayfish had high survival rates under both allopatry (100%) and sympatry (92%). There were significant differences of invasive and native crayfish growth under sympatry and allopatry ($P < 0.05$). Invasive crayfish biomass grew rapidly under both allopatry (4.43 ± 2.3 g) and sympatry (1.98 ± 0.75 g). However, invasive crayfish grew slowly in allopatry (0.62 ± 0.19 g) compared to a biomass reduction (0.83 ± 0.76 g) under sympatry with invasive crayfish. This suggests significant negative impacts of invasive red-swamp crayfish on native Piedmont crayfish growth and survival.

HABITAT USAGE AND CONSPECIFIC INTERACTIONS OF THE HARVESTMAN *CYNORTA MARGINALIS* IN A COSTA RICAN RAIN FOREST. Nathaniel Schaus, Tatyana Zvonareva, Ashley Shrives, Cynthia Richardson, Sarah Locke, Maynard H. Schaus, and Victor R. Townsend, Jr., Department of Biology, Virginia Wesleyan College. This study investigated habitat use and intraspecific interactions among adult *Cynorta marginalis*, an arboreal harvestman, at La Selva Biological Station, Costa Rica. In the field, we repeatedly sampled 15 transects (40 m in length) in the morning and evening, resulting in the capture and marking (with paint) of 146 males and 112 females. Only three individuals (all females) were recaptured, indicating that the population size at this site was relatively large. Heavy rains significantly reduced the surface activity of adults, with 0.9 individuals per transect observed during heavy rain vs. 3.6 individuals per transect during light or no rain. Harvestmen were most commonly observed using leaves as perches (65% of captures), but also used tree trunks (31%), and were rarely observed on branches or in the leaf litter. Adults were most commonly found alone on perches (85%), however, we observed several harvestmen in male-female pairs (8%), same sex pairs (4%) and heterosexual groups (7%). Although we did not observe reproductive or aggressive behaviors in the field, our observations of intraspecific interactions under laboratory conditions revealed that at least some individuals (15%) actively attempted to copulate. Aggression was not observed in intersexual trials or in interactions between females and was only rarely observed between males (1 out of 20 trials). This study was funded by a VWC Summer Faculty Development Grant (MHS) and a Virginia Foundation of Independent Colleges Mednick Fellowship (VRT).

HARVESTMAN SIZE IMPACTS THE REALIZED TROPHIC LEVEL IN A RAIN FOREST FOOD WEB. Maynard H. Schaus & Victor R. Townsend, Jr., Department of Biology, Virginia Wesleyan College. Harvestmen (Arachnida, Opiliones) are frequently thought to be omnivorous, potentially ingesting invertebrates, plant tissues, detritus, and/or fungi. However, for most harvestmen species, quantitative diet data are lacking. We quantified the diets of several harvestman species at La Selva Biological Station, Costa Rica, using multiple stable isotope analysis. For cosmetid harvestmen, there was a significant increase in $\delta^{15}N$ with body size. The diet of a cosmetid nymph was ~1 trophic level lower than that observed in adult harvestmen (*Cynorta marginalis*, *Eucynorta tenuipes*, *Cynortellana oculata*, and the sclerosomatid *Prionostemma sp*.). The trophic level of the largest species (*Eupoecilaema magnum*) was ~1/3 trophic level higher than that of other adult harvestmen. This indicates that the diet of harvestmen can vary ontogenetically, and that larger species can subdue larger prey items, which are more likely to occur at a higher

trophic level. Our results also indicate that this technique may provide valuable insight into the diet of harvestmen and can complement other analyses of diet. This study was funded by a VWC Summer Faculty Development Grant (MHS) and a Virginia Foundation of Independent Colleges Mednick Fellowship (VRT).